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**This is an application for Letters Patent of the United States of America on an invention  
entitled**

**TOOL FOR INSTALLING BLIND THREADED FASTENERS**

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## TOOL FOR INSTALLING BLIND THREADED FASTENERS

### RELATED APPLICATIONS

The present application is related to provisional patent application serial number 60/466,465 entitled "Tool for Installing Blind Threaded Fasteners" filed on April 30, 2003, priority from which is hereby claimed.

### FIELD OF THE INVENTION

This invention relates to a tool for the installation of blind threaded fasteners. More specifically, it relates to tools which include a radially-expansive shaft for gripping parts on which it operates.

### BACKGROUND OF THE INVENTION

Blind threaded fasteners are fasteners, either internally or externally threaded, that can be first installed into a hole in a panel with access to one side of the panel only, hence the term "blind". Most of these fasteners contain three basic components: a head, an intermediate collapsible thin-walled counterbored portion of the shank, and an internally threaded region at the end. Typically the threaded area and a portion of the shank are first installed into the hole and then a compressive force is applied to the shank by pulling on the threaded region while supporting the head. This compression causes the shank to buckle outwardly, creating what is known as a "bulb" on the side of the sheet opposite the head. The threaded tool member used to compress the shank is then removed, leaving the fastener permanently gripped to the panel and restrained by the head in one direction and the bulb in the opposite direction.

1           Presently available tools for applying the compressive load (upset force) to collapse the  
2 shank can be divided into two broad categories, spin-spin and spin-pull types. Both types of tools  
3 utilize an anvil, also known as a nosepiece, from which the mandrel projects. Its function is to  
4 support the head of the fastener while the mandrel retracts or spins to force the insert toward the  
5 anvil. Spin-spin tools apply the compressive load to the shank by applying enough torque to a  
6 mandrel threaded into the fastener to produce the required load. Spin-spin tools are inexpensive,  
7 lightweight and simple to set up and use and are therefore generally preferred. However, because  
8 the upset force they can develop is limited, they generally cannot be used to install parts having  
9 thicker walls. Spin-pull tools spin the mating threaded member into position, then apply an axial  
10 pulling force by retracting the mandrel. The mandrel is then removed by spinning it in the opposite  
11 direction. Spin-pull tools are more complex and consequently more expensive and heavier than  
12 spin-spin tools. They are also more difficult to set up and require more maintenance. In spite of  
13 these disadvantages, spin-pull tools are the best available choice for thick-walled parts requiring  
14 higher compressive loads to form the bulb.

15           Spin-spin tools of the existing art are rather simple devices powered by a reversible motor,  
16 pneumatic or electric. A transmission of some sort is typically used to reduce speed and increase  
17 torque. The transmission output is connected to a threaded mandrel. The mandrel is supported  
18 axially by a thrust bearing and radially by a close fit in a nosepiece. The nosepiece supports the  
19 head of the insert when the compressive load is applied. Serrations are applied to the end of the  
20 nosepiece to prevent the insert from rotating when the mandrel is tightened.

21           A spin-spin tool operates as follows. An insert is first threaded onto the mandrel. This  
22 can be done either manually or the tool can be rotationally jogged in the forward direction.

1 Regardless of whether the insert is threaded on manually or by using tool power, it must be  
2 installed until the head is just in contact with the serrated anvil. The next step is to install the  
3 body of the fastener into the hole in the panel into which it will be installed. It must be installed  
4 fully so that the underside of the head is in intimate contact with the outer surface of the panel.  
5 The tool is then activated in the forward direction and as the tool rotates, a compressive load is  
6 produced causing the fastener to form a bulb on the back side of the work piece until the tool  
7 stalls. The torque at which the tool stalls is controlled by a parameter that was adjusted during  
8 the set-up process. If the torque has been properly set it will induce enough load to properly form  
9 the bulb on the fastener but not be so great as to damage the fastener. To complete the cycle, the  
10 trigger is actuated in the reverse direction to unthread the mandrel from the installed insert.

11 Spin-pull tools of the existing art have two major components, those which produce the  
12 spinning action and those which produce the pulling action. The spinning action is provided by a  
13 reversible pneumatic or electric motor. Unless used to create the pulling force, motors are  
14 typically smaller than those used on spin-spin tools, because less torque is required.

15 Spin-pull tools operate as follows. First the tool mandrel is threaded into the insert. After  
16 the insert has been fitted to the mandrel, the body of the insert is installed into the hole in the panel  
17 into which it is to be installed. It must be installed fully so that the underside of the head is in  
18 intimate contact with the outer surface of the panel. After the insert is installed the pulling motion  
19 of the tool is initiated by the operator squeezing a trigger. Depending on the design of the tool the  
20 pulling motion continues until either a preset distance or a preset force has been achieved. The  
21 pulling motion will cause the fastener to bulb completely. After the pulling motion is complete,  
22 the mandrel spins in the reverse direction unthreading it from the fastener. Depending on the style

1 of tool, this reverse rotation is either initiated by the operator squeezing a trigger or by the tool  
2 sensing the completion of the pulling motion. After the mandrel spins out of the installed insert,  
3 the tool is ready for the next cycle.

4 Both types of tools of the existing art use a conventional threaded mandrel to engage the  
5 threads of the insert. This member needs to be started, essentially meaning its helix needs to be  
6 aligned with the helix of the insert thread. This helix alignment is complicated by the fact that  
7 most internally threaded inserts have two separate helical grooves. One is the actual thread, which  
8 is the one that needs to be aligned with the mandrel thread. The second is of smaller size, is one  
9 half turn from the true thread, and is created at the minor diameter by the way in which the insert  
10 material flows during the form tapping operation. Many internally threaded blind inserts are form  
11 tapped for increased thread strength compared to cut tapping. If the mandrel thread starts into the  
12 smaller diameter helix at the minor diameter, it will bind after a very short amount of rotation.  
13 Even if the mandrel is started properly, time is required to thread the mandrel in and then unthread  
14 it at the end of the cycle. If one assumes a rotational speed of 1500 RPM and 10 threads engaged,  
15 the total in and out time is 0.8 seconds plus the time required for the motor to accelerate to rated  
16 speed. If an additional 0.2 seconds is estimated for the two accelerations, the total time becomes  
17 1.0 second. For high volume applications, user expectations are currently for a 5.0 second total  
18 cycle time, in which case the non-productive thread in and thread out time is 20 percent of the  
19 total.

20 It is, therefore, an objective of this invention to provide an installation tool for blind-  
21 threaded inserts with force capability equal to or greater than that of existing spin-pull tools which  
22 makes it simpler to set up and use than existing spin-spin tools. It is a further objective of this

1 invention to eliminate the problems of cross-threading and mandrel wear and to reduce the time  
2 required to engage and disengage the threaded member of the tool from the insert threads.

### 3 SUMMARY OF THE INVENTION

4 In order to solve the problems in the art described above, an expanding mandrel replaces  
5 the conventional solid, threaded member to engage the threads of the insert being installed. The  
6 expanding mandrel is an externally threaded assembly having a plurality of movable segments  
7 separated by axially-extending radial slots. The segments are movable radially between a collapsed  
8 state, the condition of the mandrel segments when they are in their inward most position of  
9 minimum diameter, and an expanded state, when the mandrel segments are moved outwardly to  
10 their position of maximum diameter. The slot width is chosen such that when the mandrel is in a  
11 collapsed state the external diameter of the mandrel will pass through the minor diameter of the  
12 insert's internal thread. Like a spin-pull tool, the mandrel of the invention also extends and  
13 retracts axially, the extended position being the position of maximum extension of the mandrel  
14 from the face of the insert head support member or anvil and the retracted state being the position  
15 of the mandrel at the point of minimum protrusion from the face of the anvil.

16 The present device is a tool for installing blind threaded fasteners, comprising the  
17 following basic elements.

- 18 1) A mandrel rod including thread-like grooves comprised of multiple segments with  
19 specified design criteria in each of two positions, collapsed and expanded. In the collapsed  
20 position the effective outer diameter of the unit is slightly smaller than the minimum minor  
21 diameter of the corresponding size internal thread. In the expanded position the outer

1 surface of the unit lies essentially within the limits of size of the desired size of external  
2 thread.

3 2) Means to resist radially inward motion and further to lock the mandrel rod in the expanded  
4 position.

5 3) Means to move the mandrel rod between the collapsed state and the expanded state.

6 4) Means to support the head of the fastener during the installation process.

7 5) Means to move the mandrel rod axially forward and backward relative to the anvil.

8 6) Means to adjust the axial position of the anvil relative to the mandrel when it is in its fully  
9 extended position.

10 The operation of a hand tool constructed according to the present invention begins with the  
11 mandrel in the radially-collapsed and axially-extended state. The operator first inserts the  
12 mandrel into the insert and the tool is actuated to expand the mandrel segments against the  
13 internal threads of the insert thereby attaching the insert to the mandrel. The insert and tool are  
14 then placed into the workpiece mounting hole. Next, the tool is actuated by the operator to pull  
15 the mandrel into the nosepiece thus placing the insert in compression against the nosepiece anvil  
16 and causing it to bulb thereby gripping the insert to the workpiece. The mandrel is then returned  
17 to its collapsed state and the operator extracts the tool mandrel from the installed insert. Finally,  
18 the tool is actuated to return the mandrel to its extended state thereby completing the process.

19 The present invention offers at least three advantages over existing tools of this type.  
20 First, it provides faster cycle times by eliminating the need to thread the mandrel into the part and  
21 unthread the mandrel from the part during each cycle as is required with existing tools. Secondly,  
22 it allows automatic feeding of fasteners onto the mandrel without the need to thread the mandrel

1 into the part. And lastly, potential problems with cross-threading are eliminated because the  
2 mandrel does not need to be rotatively threaded into the part. Other objects and advantages will  
3 be apparent to those of skill in the art from the following drawings and detailed description of the  
4 preferred embodiment.

#### 5 DESCRIPTION OF THE DRAWINGS

6 Figure 1 is a partial cut-away side view of the invention in its operative position with a  
7 panel and a fastener just installed.

8 Figure 2 is a partially cross-sectioned side view of the mandrel in the radially collapsed  
9 state.

10 Figure 3 is an end view of the mandrel in the radially collapsed state.

11 Figure 4 is a partially cross-sectioned side view of the mandrel in the radially expanded  
12 state.

13 Figure 5 is an end view of the mandrel in the radially expanded state.

14 Figure 6 is a partially cross-sectioned side view of the mandrel and nosepiece in the fully  
15 extended position for an insert of a given grip length.

16 Figure 7 is a partially cross-sectioned side view of the mandrel and nosepiece in the fully  
17 extended position for an insert of a different, longer grip than shown in Figure 6.

18 Figure 8 is a partially cross-sectioned side view of the tool with the mandrel in the  
19 collapsed, fully extended state axially engaged with an insert.

20 Figure 9 is a partially cross-sectioned side view of the tool with the mandrel in the  
21 expanded, fully extended state and axially and radially engaged with an insert.



1           Figure 10 is a partially cross-sectioned side view of the tool with the mandrel in the  
2           expanded state and axially at the stopping point with the fastener in the fully bulbed condition.

3           Figure 11 is a partially cross-sectioned side view of the tool with the mandrel in the  
4           collapsed, retracted state, disengaged from the insert thread.

#### 5           DESCRIPTION OF THE PREFERRED EMBODIMENT

6           Referring to Figure 1, an overall view of the installation tool of the invention is shown  
7           positioned against the panel with an insert engaged with the expanding mandrel ready to be  
8           installed. While the invention is suitable for use with a robotic device, this embodiment is depicted  
9           in the form of a hand tool having a body 30, a handle 31, and rocker-type on/off switch 32. As  
10          will be more fully described below, the novel expanding mandrel includes a spreading pin 39  
11          operated by hydraulic cylinder 29. Pneumatic cylinder 33 provides the pull force to compress the  
12          insert 36. The tool includes a forwardly-extending nosepiece 34 having an insert head support  
13          anvil 35 that abuts the head of the insert 36 during installation. In this figure, the insert has just  
14          been installed and a bulb 37 has formed on the insert against the backside of panel 38.

15          Details of the expanding mandrel construction can be understood with reference to Figures  
16          2 through 5. The mandrel slot width 41 is chosen such that the maximum effective diameter in the  
17          collapsed position 42 shown in Figure 3 is just under the minimum minor diameter of the internal  
18          thread. The weakest cross-section of the mandrel segment is in the threaded area. The  
19          unthreaded section of the mandrel is designed so that the wall thickness 43 in the unthreaded area  
20          is always greater than in the threaded area to preserve maximum tensile strength of the mandrel  
21          segments. Consideration is also given to the minimum diameter of the spreading pin 44 so that it  
22          will not fail in compression.

1           Details of the head support anvil and the means used to adjust its axial position relative to  
2 the expanding mandrel assembly can be understood with reference to Figures 6 and 7. The insert  
3 45 shown in Figure 6 is designed for a shorter grip and therefore has a shorter counterbore than  
4 the insert 46 shown in Figure 7. For full thread engagement, the expanding mandrel therefore  
5 needs to project farther from the face of head support anvil 5 for the insert 46 with the longer  
6 counterbore than for insert 45 shown in Figure 6. This is accomplished by providing the anvil  
7 with a threaded adjustment means 47 and jam nut 48. Note the difference between the gap 49 in  
8 Figure 6 and the gap 50 in Figure 7.

9           In the preferred embodiment shown in Figure 8 and following, the pulling force is applied  
10 with a double-acting pneumatic cylinder 1 which has a hollow cylinder rod 2. A second hydraulic  
11 cylinder 3 is attached to one end of the hollow cylinder rod 2. The expanding mandrel assembly 4  
12 is attached to the opposite end of the hollow cylinder rod 2. The head support anvil 5 is  
13 adjustably attached to the body of the double acting pneumatic cylinder 1. The rod 6 of the  
14 second cylinder 3 is connected to a spreading pin 7, which is used to expand the segments 8 of the  
15 expanding mandrel. The pin includes a cylindrical portion and a substantially conical wedge  
16 surface at the forward tip. A garter assembly 9 forces the segments 8 of the expanding mandrel  
17 into the collapsed state when the spreading pin 7 is removed.

18           The sequence of operation of the preferred embodiment starts with the mandrel in the  
19 radially-collapsed and fully extended state as shown in Figure 8. An insert 10 is in correct axial  
20 position, but is not yet in contact with the collapsed mandrel. To keep the mandrel in the  
21 collapsed position, fluid pressure is applied to port 11 and removed from port 12. The first action  
22 required is the expansion of the mandrel to engage the threads 15 of the insert 10 achieved by

1 applying fluid pressure to port 12 and removing it from port 11. This pressurization causes the  
2 spreading pin 7 to move axially forward and the conical tip of the spreading pin wedges the  
3 mandrel segments 8 outwardly to the expanded state such that the thread-like portions of the  
4 mandrel segments 16 become engaged with the insert threads 15. The resulting position is shown  
5 in Figure 9. It should be noted that a locked position is achieved by the cylindrical portion of the  
6 spreading pin which lies parallel to the surface of the inner walls of the segment, thereby achieving  
7 a direct block between opposing segments locking them in the expanded state without force  
8 feedback on the pin in the axial direction.

9         Since the mandrel is now engaged with the insert, the insert will move with the tool when  
10 the tool is moved. The next action in the sequence is to move the tool to the workpiece and to  
11 insert the insert body 17 in the hole 18 in the workpiece 19. After the insert has been installed  
12 completely so that the underside of the head 20 is in intimate contact with the outer surface 21 of  
13 the workpiece 19, the pulling action is initiated by applying air pressure to port 14 and removing it  
14 from port 13. This pressurization causes the hollow cylinder rod 2 to pull on the expanding  
15 mandrel assembly 4 moving insert head 22 against the head support anvil 23 of the tool nosepiece  
16 placing the counterbored area of the insert 24 in compression.

17         As shown in Figure 10, the compressive load causes the thin-walled counterbored area to  
18 buckle outward creating a bulb 25 which captivates the insert to the workpiece. The pulling  
19 continues until it is ended by the tool control program which can be based on different factors.  
20 Pull-to-stroke tools pull until a predetermined stroke is achieved. Pull-to-force tools pull until a  
21 predetermined force is achieved. Tools using other control schemes pull until the control logic

generates a stop signal. When the pulling is complete fluid pressure is removed from port 14 and port 13 causing the mandrel to hold its position regardless of how the tool is controlled.

The next action in the operational sequence is the disengagement of the mandrel from the installed insert. This is accomplished in two steps, radial movement of the mandrel segments 8 followed by axial movement of the mandrel assembly 4. The radial movement is initiated by applying fluid pressure to port 11 and removing it from port 12. This pressurization causes the spreading pin 7 to move axially backward and retract from between the mandrel segments 8 allowing the garter assembly 9 to force the mandrel segments to the collapsed state around the smaller diameter cylindrical portion of the pin. This disengages the segments from the insert threads 15. The tool can now be moved axially away from the installed insert 27. The resulting final position is shown in Figure 11.

In choosing the dimensions of the expanding mandrel, the thread minor diameter must be used as the outer diameter for area calculations. This differs from the tensile stress area diameter normally used, which is larger, nearly equal to the pitch diameter. The minor diameter must be used because the slotting of the mandrel cuts through the thread helix so that there is no longer any additive strength from the helix. The slot width and number of segments must be arranged so that when the mandrel is in the fully collapsed position, it will pass through the minimum minor diameter of the internal thread. As the number of segments is increased, the combined area of all the sections and therefore the strength of the assembly increases. However, experimentation has shown that, starting with four segments, the incremental strength increase from additional segments significantly decreases and beyond eight segments the incremental increase is negligible. Therefore, the preferred embodiment uses four segments.

1           The preferred embodiment described above can be applied equally well to a hand-held tool  
2   or to an automated tool. Other embodiments are also possible and are anticipated within the  
3   scope of this invention. Specifically, other embodiments using different means to actuate the  
4   mandrel between the expanded, locked and collapsed states can be made as can other  
5   embodiments using different means to actuate the mandrel between the fully extended state and  
6   the stopping point. Therefore, it will be apparent to those of skill in the art that there may be  
7   many other embodiments which will become apparent from the teachings herein. It should be  
8   understood, however, that the spirit and scope of the invention is to be defined only by the  
9   following claims and their legal equivalents.